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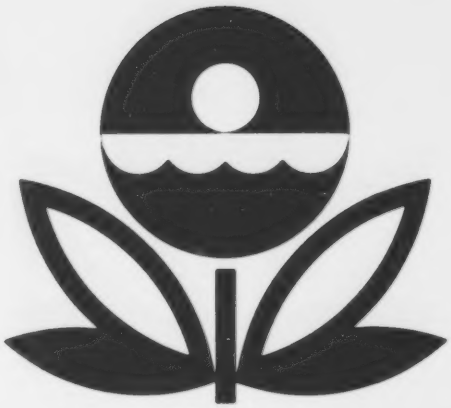

REPORT

ON

LAKE HENSHAW

SAN DIEGO COUNTY

CALIFORNIA

EPA REGION IX

WORKING PAPER No. 748

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
LAKE HENSHAW
SAN DIEGO COUNTY
CALIFORNIA

EPA REGION IX

WORKING PAPER No. 743

WITH THE COOPERATION OF THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

AND THE

CALIFORNIA NATIONAL GUARD

JUNE, 1978

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentration (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the California State Water Resources Control Board and the nine Regional Water Quality Control Boards for professional involvement, to the California National Guard for conducting the tributary sampling phase of the Survey, and to those California wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Division of Planning and Research of the State Water Resources Control Board provided invaluable lake documentation and counsel during the Survey, coordinated the reviews of the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

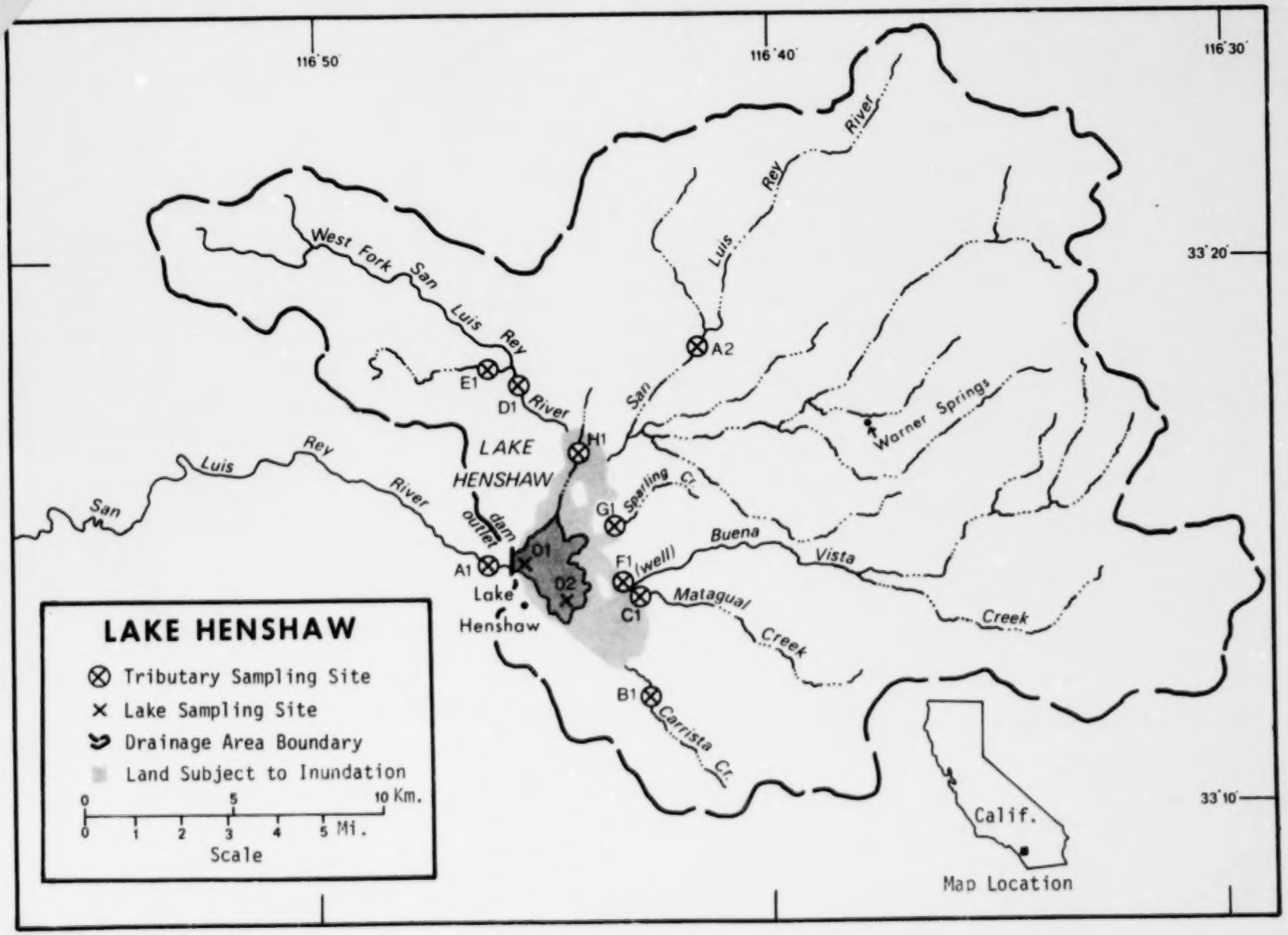
Major General Glen C. Ames, the Adjutant General of California, and Project Officer Second Lieutenant Terry L. Barrie, who directed the volunteer efforts of the California National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of California

Name	County
Amador	Amador
Boca	Nevada
Britton	Shasta
Casitas	Ventura
Crowley	Mono
Don Pedro	Tuolumne
Elsinore	Riverside
Fallen Leaf	El Dorado
Hennessey	Napa
Henshaw	San Diego
Iron Gate	Siskiyou
Lopez	San Luis Obispo
Mary	Mono
Mendocino	Mendocino
Nicasio	Marin
Lower Otay	San Diego
Pillsbury	Lake
Santa Margarita	San Luis Obispo
Shasta	Shasta
Shaver	Fresno
Silver	Mono
Tahoe	El Dorado, Placer, CA; Carson City, Douglas, Washoe, NV
Tulloch	Calaveras, Tuolumne
Lower Twin	Mono
Upper Twin	Mono


116°50'
116°40'
116°30'
33°20'
33°10'
West Fork San Luis Rey River
San Luis Rey River
LAKE HENSHAW
dam outlet
Lake Henshaw
Warner Springs
Sperling Cr.
Buena Vista Creek
Matagual Creek
Carrista Cr.
(well)
A1
A2
B1
C1
D1
E1
F1
G1
H1
O1
O2
LAKE HENSHAW
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Land Subject to Inundation
0 5 10 Km.
0 1 2 3 4 5 Mi.
Scale
Calif.
Map Location

LAKE HENSHAW

STORET NO. 0610

I. CONCLUSIONS

A. Trophic Condition*:

Survey data indicate Lake Henshaw is eutrophic. It ranked twenty-first in overall trophic quality among the 24 California lakes and reservoirs sampled in 1975 when compared using a combination of six water quality parameters**. Twenty water bodies had less median total phosphorus and dissolved orthophosphorus, 15 had less and one had the same median inorganic nitrogen, 22 had less mean chlorophyll a, and 20 had greater mean Secchi disc transparency. No significant depression of dissolved oxygen occurred during Survey sampling; however, destratification equipment has been installed in this reservoir (Bailey, 1977).

Survey limnologists noted submerged macrophytes in the southeast end of the reservoir in March and June. Surface concentrations of algae were noted at both sampling stations in March and November.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Henshaw was nitrogen limited at the time the sample was collected (03/07/75). The reservoir data indicate nitrogen limitation at both stations and at all sampling times.

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* Trophic assessment is based on levels of nutrients, dissolved oxygen, and chlorophyll a; phytoplankton kinds and numbers; and transparency (Allum et al., 1977).

** See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known point sources impacted Lake Henshaw during the sampling year.

The estimated phosphorus loading of 0.09 g/m^2 measured during the sampling year is a little less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (see page 14). However, the eutrophic condition of Lake Henshaw and the apparent loss of phosphorus during the sampling year (page 11), indicate an underestimation of phosphorus inputs (see discussion below). Also, the area of the reservoir at maximum pool was used to calculate the areal loading; if the mid-summer area of 3.67 km^2 (Johns, 1975) is used, the loading would be 0.58 $g/m^2/yr$ or nearly three times Vollenweider's eutrophic rate. Further, if it is assumed that the incoming phosphorus load is at least equal to the load leaving the reservoir (i.e., no phosphorus retention) the areal loading at maximum pool would be 0.23 $g/m^2/year$.

The apparent loss of phosphorus from the reservoir may have been the result of unmeasured loads from the immediate drainage area. Survey limnologists observed cattle grazing and watering along much of the shoreline in June and November and reported that the pasture areas appeared to be subject to periodic inundation. Depending on animal densities, such inundation could result in a significant phosphorus load to

the reservoir. In this regard, note that the mean total phosphorus concentration at the outlet (0.213 mg/l) was over four times the mean of the concentrations in the five sampled tributaries (page 13).

2. Non-point sources--Non-point sources accounted for all of the total phosphorus input to the reservoir during the sampling year. The San Luis Rey River contributed an estimated 16.6%, the West Fork added 5.4%, and the ungaged minor tributaries and immediate drainage contributed an estimated 57.9% of the total load.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 24.36 kilometers^2.
2. Mean depth: 6.1 meters.
3. Maximum depth: 10.7 meters.
4. Volume: 148.596 x 10^6 m^3.
5. Mean hydraulic retention time: 5.7 years.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
San Luis Rey River	87.0	0.156
W. Fk., San Luis Rey River	66.0	0.125
Minor tributaries & immediate drainage -	356.1	0.682
Totals	509.1	0.964

2. Outlet -

San Luis Rey River	533.5**	0.820

C. Precipitation***:

1. Year of sampling: 33.6 centimeters.
2. Mean annual: 35.7 centimeters.

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† Table of metric equivalents--Appendix B.
†† Johns, 1975.
* For limits of accuracy, see Working Paper No. 175, "... Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Lake Henshaw was sampled three times in 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from one or more depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 6.1 meters at station 1 and 1.2 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE MENSHAW
STORET CODE 0610

PARAMETER	1ST SAMPLING (3/ 7/75) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (6/23/75) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (11/13/75) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	10.3 - 11.6	10.7	10.5	18.0 - 21.4	19.6	19.5	10.9 - 11.0	11.0	11.0
DISS OXY (MG/L)	7.6 - 9.0	8.3	8.2	5.2 - 8.4	7.5	7.9	8.6 - 8.8	8.7	8.7
CNDCTVY (MCROMO)	603. - 624.	614.	618.	520. - 560.	540.	540.	415. - 437.	426.	425.
PH (STAND UNITS)	7.9 - 8.3	8.1	8.1	8.6 - 8.9	8.8	8.8	8.3 - 8.4	8.4	8.4
TOT ALK (MG/L)	162. - 165.	164.	164.	168. - 172.	170.	171.	191. - 196.	194.	194.
TOT P (MG/L)	0.114 - 0.125	0.120	0.119	0.256 - 0.274	0.262	0.260	0.128 - 0.141	0.134	0.134
ORTHO P (MG/L)	0.062 - 0.067	0.063	0.062	0.211 - 0.232	0.218	0.216	0.071 - 0.083	0.075	0.072
NO2+NO3 (MG/L)	0.020 - 0.020	0.020	0.020	0.020 - 0.030	0.022	0.020	0.080 - 0.080	0.080	0.080
AMMONIA (MG/L)	0.030 - 0.058	0.044	0.050	0.020 - 0.050	0.032	0.030	0.020 - 0.030	0.022	0.020
KJEL N (MG/L)	0.400 - 1.100	0.600	0.500	0.600 - 1.100	0.767	0.700	0.500 - 0.600	0.525	0.500
INORG N (MG/L)	0.050 - 0.070	0.064	0.070	0.040 - 0.080	0.053	0.050	0.100 - 0.110	0.102	0.100
TOTAL N (MG/L)	0.420 - 1.120	0.620	0.520	0.620 - 1.120	0.788	0.725	0.580 - 0.680	0.605	0.580
CHLRPYL A (UG/L)	26.6 - 32.1	29.3	29.3	6.5 - 6.7	6.6	6.6	44.4 - 44.4	44.4	44.4
SECCHI (METERS)	0.3 - 0.3	0.3	0.3	1.5 - 1.8	1.7	1.7	******	**********	

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera		Algal Units per ml
03/07/75	1.	Mallomonas sp.	7,701
	2.	Chroomonas (?) sp.	553
	3.	Ankistrodesmus sp.	277
	4.	Cryptomonas sp.	184
	5.	Melosira sp.	184
		Other genera	323
		Total	9,222
06/23/75	1.	Microcystis sp.	987
	2.	Ankistrodesmus sp.	816
	3.	Glenodinium sp.	258
	4.	Chroomonas (?) sp.	258
	5.	Kirchneriella sp.	215
		Other genera	728
		Total	3,262
11/13/75	1.	Oscillatoria sp.	681
	2.	Chroomonas (?) sp.	367
	3.	Ankistrodesmus sp.	314
	4.	Pediastrum sp.	209
	5.	Melosira sp.	209
		Other genera	577
		Total	2,357

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
03/07/75	1	26.6
	2	32.1
06/23/75	1	6.5
	2	6.7
11/13/75	1	44.4
	2	44.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.075	0.152	7.6
0.050 P	0.125	0.152	7.7
0.050 P + 1.0 N	0.125	1.152	40.1
1.0 N	0.075	1.152	36.6

2. Discussion -

The control yield of the assay alga, *Selenastrum capricornutum*, indicates that the potential primary productivity of Lake Henshaw was high at the time the sample was collected (03/07/75). Also, the lack of significant increase in yield with the addition of phosphorus until nitrogen was also added indicates nitrogen limitation at that time. Note that the addition of nitrogen alone resulted in a yield much greater than that of the control.

The reservoir data also indicate nitrogen limitation. The mean inorganic nitrogen/orthophosphorus ratios at both sampling stations were 1/1 or less, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the California National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of March when two samples were collected. Sampling was begun in November, 1974, and was completed in October, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the California District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for unsampled San Luis Rey River at station A-2 were estimated using the mean nutrient concentrations measured at station H-1 and the mean river flow.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations at stations B-1, F-1, and G-1 and the mean ZZ flow.

No known wastewater treatment plants impacted the reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
San Luis Rey River	350	16.6
W. Fk., San Luis Rey River	115	5.4
b. Minor tributaries & immediate drainage (non-point load) -	1,225	57.9
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	425	20.1
Total	2,115	100.0

2. Outputs -

Reservoir outlet - San Luis Rey River 5,510

3. Net annual P loss - 3,395 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
San Luis Rey River	7,415	10.5
W. Fk., San Luis Rey River	5,530	7.9
b. Minor tributaries & immediate drainage (non-point load) -	31,120	44.2
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	26,300	37.4
Total	70,365	100.0

2. Outputs -

Reservoir outlet - San Luis River 39,460

3. Net annual N accumulation - 30,905 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
San Luis Rey River	4	85
W. Fk., San Luis Rey River	2	84

* See Working Paper No. 175.

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Carista Creek	0.057	1.572
Unnamed Stream E-1	0.020	0.860
Unnamed Stream F-1	0.047	1.559
Sparling Creek	0.065	1.232
Unnamed Stream H-1	0.071	1.507

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.09	loss*	2.9	1.3

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Henshaw:	
"Dangerous" (eutrophic loading)	0.20
"Permissible" (oligotrophic loading)	0.10

* There was an apparent loss of phosphorus during the sampling year. This would not be expected to occur and may be indicative of unsampled point sources discharging directly to the reservoir, resolubilization of previously sedimented phosphorus, recharge with phosphorus-rich groundwater, or underestimation of the immediate drainage load (see page 2).

V. LITERATURE REVIEWED

Allum, M.O., R.E. Glessner, and J.H. Gakstatter, 1977. An evaluation of the National Eutrophication Survey data. Working Paper No. 900, Corvallis Env. Res. Lab., Corvallis OR.

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Johns, Gerald E., 1975. Personal communication (water quality information). CA Water Res. Contr. Bd., Sacramento.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
0601	AMADOR RESERVOIR	0.040	0.390	408.667	22.383	14.600	0.020
0602	BOCA LAKE	0.012	0.040	372.833	1.700	6.800	0.003
0603	LAKE BRITTON	0.067	0.115	448.500	4.811	11.200	0.047
0604	CASITAS RESERVOIR	0.029	0.050	400.250	3.192	14.000	0.014
0605	CROWLEY LAKE	0.046	0.045	374.750	5.800	12.200	0.034
0606	DON PEDRO RESERVOIR	0.013	0.060	381.733	3.564	11.400	0.004
0607	LAKE ELSINORE	0.469	0.120	489.214	70.572	8.000	0.092
0608	FALLEN LEAF RESERVOIR	0.007	0.040	24.357	0.786	8.800	0.005
0609	LAKE HENNESSEY	0.027	0.060	416.000	4.525	15.000	0.012
0610	LAKE HENSHAW	0.138	0.070	461.000	26.783	9.800	0.073
0611	IRON GATE RESERVOIR	0.184	0.690	440.333	6.217	13.800	0.124
0614	LOPEZ LAKE	0.371	0.090	372.000	8.658	15.000	0.343
0615	LAKE MARY	0.010	0.040	296.000	2.550	10.600	0.002
0616	LAKE MENDOCINO	0.020	0.050	436.500	3.100	9.400	0.008
0617	NICASIO RESERVOIR	0.055	0.345	482.778	6.633	9.800	0.013
0618	LOWER OTAY RESERVOIR	0.058	0.180	447.250	15.933	15.000	0.013
0619	LAKE PILLSBURY	0.022	0.060	466.667	6.389	8.200	0.008
0620	SANTA MARGARITA LAKE	0.037	0.070	400.000	9.122	14.800	0.014
0621	SHASTA LAKE	0.021	0.060	381.542	4.087	9.000	0.015
0622	SHAVER	0.014	0.060	346.400	1.700	7.400	0.004
0623	SILVER LAKE	0.012	0.055	356.000	1.800	7.000	0.003
0624	TULLOCK RESERVOIR	0.025	0.060	433.000	13.878	7.400	0.009
0625	UPPER TWIN LAKES	0.015	0.040	300.200	3.340	7.400	0.004
0626	LOWER TWIN LAKES	0.014	0.040	248.000	2.900	1..400	0.003

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	1S-MIN DO	MEDIAN DISS ORTHO P	INDEX NU
0601	AMADOR RESERVOIR	35 (8)	4 (1)	43 (10)	9 (2)	17 (4)	26 (6)	134
0602	BOCA LAKE	89 (20)	98 (22)	70 (16)	91 (21)	100 (23)	91 (20)	539
0603	LAKE BRITTON	17 (4)	22 (5)	17 (4)	48 (11)	43 (10)	17 (4)	164
0604	CASITAS RESERVOIR	43 (10)	74 (17)	48 (11)	70 (16)	22 (5)	37 (8)	294
0605	CROWLEY LAKE	30 (7)	78 (18)	65 (15)	43 (10)	30 (7)	22 (5)	268
0606	DON PEDRO RESERVOIR	83 (19)	54 (11)	57 (13)	61 (14)	37 (8)	78 (17)	370
0607	LAKE ELSINORE	0 (0)	17 (4)	0 (0)	0 (0)	78 (18)	9 (2)	104
0608	FALLEN LEAF RESERVOIR	100 (23)	87 (19)	100 (23)	100 (23)	70 (16)	70 (16)	527
0609	LAKE HENNESSEY	48 (11)	54 (11)	39 (9)	52 (12)	4 (0)	52 (12)	249
0610	LAKE HENSHAW	13 (3)	33 (7)	13 (3)	4 (1)	54 (12)	13 (3)	130
0611	IRON GATE RESERVOIR	9 (2)	0 (0)	26 (6)	39 (9)	26 (6)	4 (1)	104
0614	LOPEZ LAKE	4 (1)	26 (6)	74 (17)	26 (6)	4 (0)	0 (0)	134
0615	LAKE MARY	96 (22)	87 (19)	91 (21)	83 (19)	48 (11)	100 (23)	505
0616	LAKE MENDOCINO	65 (15)	70 (16)	30 (7)	74 (17)	61 (14)	63 (14)	363
0617	NICASIO RESERVOIR	26 (6)	9 (2)	4 (1)	30 (7)	54 (12)	46 (10)	169
0618	LOWER OTAY RESERVOIR	22 (5)	13 (3)	22 (5)	13 (3)	4 (0)	46 (10)	120
0619	LAKE PILLSBURY	57 (13)	41 (9)	9 (2)	35 (8)	74 (17)	63 (14)	279
0620	SANTA MARGARITA LAKE	39 (9)	33 (7)	52 (12)	22 (5)	13 (3)	37 (8)	196
0621	SHASTA LAKE	61 (14)	54 (11)	61 (14)	57 (13)	65 (15)	30 (7)	328
0622	SHAVER	78 (18)	41 (9)	83 (19)	96 (22)	87 (19)	78 (17)	463
0623	SILVER LAKE	89 (20)	65 (15)	78 (18)	87 (20)	96 (22)	91 (20)	506
0624	TULLOCK RESERVOIR	52 (12)	54 (11)	35 (8)	17 (4)	87 (19)	57 (13)	302
0625	UPPER TWIN LAKES	70 (16)	98 (22)	87 (20)	65 (15)	87 (19)	78 (17)	485
0626	LOWER TWIN LAKES	74 (17)	87 (19)	96 (22)	78 (18)	37 (8)	91 (20)	463

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	0602	BOCA LAKE	539
2	0608	FALLEN LEAF RESERVOIR	527
3	0623	SILVER LAKE	506
4	0615	LAKE MARY	505
5	0625	UPPER TWIN LAKES	485
6	0626	LOWER TWIN LAKES	463
7	0622	SHAVER	463
8	0606	DON PEDRO RESERVOIR	370
9	0616	LAKE MENDOCINO	363
10	0621	SHASTA LAKE	328
11	0624	TULLOCK RESERVOIR	302
12	0604	CASITAS RESERVOIR	294
13	0619	LAKE PILLSBURY	279
14	0605	CROWLEY LAKE	268
15	0609	LAKE HENNESSEY	249
16	0620	SANTA MARGARITA LAKE	196
17	0617	NICASIO RESERVOIR	169
18	0603	LAKE BRITTON	164
19	0614	LOPEZ LAKE	134
20	0601	AMADOR RESERVOIR	134
21	0610	LAKE HENSHAW	130
22	0618	LOWER OTAY RESERVOIR	120
23	0607	LAKE ELSINORE	104
24	0611	IRON GATE RESERVOIR	104

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 - cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 11/30/76

LAKE CODE 0610 LAKE HENSHAW

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 533.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0610A1	533.5	0.75	3.08	2.49	1.44	0.49	0.25	0.25	0.24	0.18	0.12	0.13	0.59	0.82
0610A2	87.0	0.267	0.634	0.392	0.175	0.050	0.017	0.008	0.004	0.008	0.000	0.100	0.250	0.156
0610D1	66.0	0.181	0.326	0.366	0.354	0.072	0.022	0.005	0.002	0.002	0.002	0.031	0.147	0.125
0610ZZ	66.0	1.170	2.791	1.711	0.774	0.216	0.072	0.036	0.018	0.036	0.002	0.441	1.080	0.682

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 533.5 TOTAL FLOW IN = 11.76
SUM OF SUB-DRAINAGE AREAS = 219.1 TOTAL FLOW OUT = 10.03

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0610A1	11	74	0.0	23	0.0				
	12	74	0.0	22	0.0				
	1	75	0.146	18	0.266				
	2	75	0.365	13	0.266	22	0.510		
	3	75	0.394	8	0.340	15	0.311		
	4	75	0.216						
	5	75	0.374	18	0.538	19	0.538	29	0.368
	6	75	0.603						
	7	75	0.754						
	8	75	0.536						
	9	75	0.459						
	10	75	0.216						
0610A2	11	74	0.0	23	0.0				
	12	74	0.0						
	1	75	0.0	18	0.0				
	2	75	0.0	13	0.0	22	0.0		
	3	75	0.0	8	0.0				
	4	75	0.0						
	5	75	0.0	18	0.0	19	0.0	29	0.0
	6	75	0.0						
	7	75	0.0						
	8	75	0.0						
	9	75	0.0						
	10	75	0.0						

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 11/30/76

LAKE CODE 0610 LAKE HENSHAW

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
061001	11	74	0.000	23	0.0				
	12	74	0.000						
	1	75	0.000	18	0.001				
	2	75	0.028	13	0.043	22	0.013		
	3	75	0.348	8	1.416	15	0.481		
	4	75	0.430						
	5	75	0.110	18	0.102	19	0.102	29	0.051
	6	75	0.012						
	7	75	0.001						
	8	75	0.000						
	9	75	0.0						
	10	75	0.0						
061022	11	74	0.001						
	12	74	0.006						
	1	75	0.001						
	2	75	0.048						
	3	75	0.651						
	4	75	0.850						
	5	75	0.195						
	6	75	0.020						
	7	75	0.002						
	8	75	0.001						
	9	75	0.001						
	10	75	0.0						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/09/24

061001
33 14 11.0 116 45 10.0 3
LAKE HENSHAW
06073 CALIFORNIA
140891

11EPALES 2111202
0024 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/07	14 55	0000	10.5	7.6	12	624	7.90	165	0.050	1.100	0.020K	0.062
	14 55	0005	10.7	8.6		618	8.00	164	0.040	0.500	0.020K	0.062
	14 55	0015	10.4	8.0		621	8.10	163	0.050	0.400	0.020K	0.063
	14 55	0020	10.3	8.2		604	8.10	164	0.050	0.400	0.020K	0.062
75/06/23	15 25	0000	19.6	8.4	72	540	8.80	170	0.030	0.900	0.020K	0.215
	15 25	0004	19.5	7.2		540	8.80	168	0.030	1.100	0.020K	0.220
	15 25	0010	18.1	7.6		520	8.90	170	0.020	0.700	0.020K	0.218
	15 25	0016	18.0	5.2		520	8.60	171	0.050	0.700	0.030	0.232
75/11/13	14 45	0000	11.0	8.6		437	8.30	191	0.020	0.600	0.080	0.083
	14 45	0005	11.0	8.6		415	8.35	193	0.030	0.500	0.080	0.072
	14 45	0015	10.9	8.8		434	8.40	195	0.020	0.500	0.080	0.071

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/07	14 55	0000	0.125	26.6	
	14 55	0005	0.119		
	14 55	0015	0.115		
	14 55	0020	0.114		
75/06/23	15 25	0000	0.256	6.5	
	15 25	0004	0.260		
	15 25	0010	0.262		
	15 25	0016	0.274		
75/11/13	14 45	0000	0.141	44.4	
	14 45	0005	0.128		
	14 45	0015	0.131		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

061002
33 13 22.0 116 44 14.0 3
LAKE HENSHAW
06073 CALIFORNIA 140892

11EPALES 2111202
0006 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/07	16 30	0000	11.6	9.0	12	603	8.30	162	0.030	0.600	0.020K	0.067
75/06/23	16 05	0000	21.4	8.4	60	560	8.90	171	0.030	0.600	0.020K	0.213
	16 05	0004	21.2	8.2		560	8.90	172	0.030	0.600	0.020K	0.211
75/11/13	15 00	0000	11.0	8.8		416	8.40	196	0.020	0.500	0.080	0.073

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/07	16 30	0000	0.125	32.1	
75/06/23	16 05	0000	0.261	6.7	
	16 05	0004	0.260		
75/11/13	15 00	0000	0.138	44.4	

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/09/24

061041
33 14 20.0 116 46 07.0 4
SAN LUIS REY RIVER
06 7.5 MESA GRANDE
O/LAKE MENSHA* 140891
MED DTY RD BRDG .7 MI NW OF GRAND STATN
11E-ALES 211204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/12/22			0.004	3.100	0.160	0.107	0.290
75/01/18	10 15		0.012	1.000	0.028	0.055	0.120
75/02/13	09 36		0.040	1.100	0.032	0.072	0.170
75/02/22	10 20		0.040	1.200	0.062	0.072	0.100
75/03/08	08 35		0.010	2.500	0.050	0.075	0.160
75/03/15	09 30		0.010	1.000	0.015	0.040	0.140
75/05/18	10 50		0.065	1.750	0.045	0.095	0.150
75/05/19	09 10		0.020	1.250	0.055	0.180	0.190
75/04/21	09 00		0.050	1.300	0.100	0.360	0.500
75/10/20	10 00		0.005	0.800	0.165	0.070	0.310

STORET RETRIEVAL DATE 76/09/24

061081
33 12 00.0 116 42 35.0 4
CARLSTA CREEK
06 7.5 WARNERS RNCH
T/LAKE MENSHA# 140892
BNK 20 FT BELO CONFLNC WITH CARRIZO CRK
11EMALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/23	10	10	0.040	3.900	0.045	0.045	0.045
74/12/22			0.012	2.350	0.077	0.045	
75/01/18	10	35	0.012	2.050	0.032	0.040	0.042
75/02/13	10	05	0.024	0.300	0.016	0.032	0.040
75/02/22	11	00	0.024	0.400	0.024	0.031	0.033
75/03/09	08	45	0.055	1.800	0.030	0.030	0.030
75/03/15	09	45	0.062	2.200	0.018	0.033	0.040
75/05/18	10	55	0.140	1.300	0.025	0.035	0.040
75/05/19	09	25	0.065	0.250	0.015	0.035	0.040
75/05/24	14	15	0.110	1.150	0.070	0.175	0.200
75/10/20	10	15	0.045	1.100	0.025	0.055	0.060

STORET RETRIEVAL DATE 76/09/24

061001
33 17 54.0 116 46 06.0 4
W FK SAN LUIS REY RIV
06 7.5 WARNERS RANC
MT/LAKE MENSHAW 140891
5000 FT SW W FRK MNR CMP USGS GAGE ST
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
75/02/13	12 00		0.008	1.400	0.016	0.016	0.030
75/02/22	13 05		0.016	0.500	0.024	0.016	0.016
75/03/08	09 20		0.005	1.600	0.022	0.020	0.030
75/03/15	10 30		0.006	1.400	0.015	0.024	0.030
75/05/19	10 30		0.010	1.450	0.045	0.020	0.030
75/05/29	15 00		0.075	1.450	0.035	0.035	0.040

STORET RETRIEVAL DATE 76/09/24

061JE1
33 17 55.0 116 46 07.0 4
UNNAMED STREAM
06 7.5 PALOMAR OBSV
T/LAKE MENSHAW 140891
UNMPRVD RD .8 MI NW XING #ITM & FRK SLRR
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
75/02/13	12	15	0.008	0.200	0.008	0.008K	0.020
75/02/22	13	20	0.016	1.000	0.032	0.006K	0.010K
75/03/08	10	30	0.005	0.900	0.030	0.010	0.020
75/03/15	10	45	0.009	2.350	0.026	0.015	0.030
75/05/18	11	40	0.010	0.750	0.015	0.010	0.010
75/05/19	10	15	0.005	0.100	0.015	0.020	0.020
75/05/24	15	15	0.070	0.600	0.025	0.020	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

0610F1
33 14 02.0 116 43 20.0 4
UNNAMED STREAM
06 7.5 WARNERS RNCH
T/LAKE MENSHAW 140892
CLVRT 2 MI NW JCT WITH HWY 79
11E-ALES 211204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/23	10	43	0.416	4.000	0.050	0.040	0.040
75/01/18	12	20	0.392	1.500	0.032	0.050	0.060
75/02/13	13	50	0.368		0.008K	0.048	0.048
75/03/04	10	40	0.390	0.500	0.010	0.050	0.050
75/03/15	11	35	0.380	2.100	0.018	0.055	0.060
75/05/14	12	20	0.380	0.300	0.005K	0.050	0.050
75/05/19	11	20	0.420	0.400	0.010		0.040
75/05/29	16	30	0.080	1.550	0.030	0.015	0.030
75/09/21	11	15	0.360	0.100	0.010	0.045	0.050
75/10/20	12	45	0.360	0.400	0.005K	0.045	0.045

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

061001
33 15 04.0 116 43 27.0 4
SPARLING CREEK
06 7.5 WARNER SPRGS
T/LAKE HENSHAW 140891
2.3 MI W JCT HWY 79 5.0 MI SW WRNR SPRNG
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/23	10 56		0.672	2.600	0.035	0.040	0.040
75/01/18	12 28		0.600	0.800	0.016	0.050	0.050
75/02/13	14 15		0.600	0.400	0.008	0.048	0.070
75/02/22	13 40		0.600	0.400	0.016	0.048	0.064
75/03/08	10 45		0.600	0.050K	0.005	0.060	0.100
75/03/15	11 20		0.617	0.300	0.015	0.065	0.110
75/05/18	12 15		0.600	0.300	0.005K	0.050	0.050
75/05/19	10 45		0.430	1.150	0.025	0.035	0.040
75/05/29	15 40		0.470	0.200	0.005K	0.045	0.050
75/09/21	11 00		0.750	0.400	0.010	0.050	0.100
75/10/20	12 20		0.610	0.400	0.005	0.045	0.045

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

0610M1
33 16 30.0 116 44 12.0 4
UNNAMED STREAM
06 7.5 WARNER SPRGS
T/LAKE HENSHAW 140891
CLVRT ON UNPVD RD 6 MI W OF WARNER SPRGS
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/23	11	27	0.736	2.200	0.030	0.035	0.040
75/01/18	11	30	0.564	0.500	0.024	0.035	0.040
75/02/13	12	35	0.680	1.300	0.016	0.064	0.180
75/02/22	13	35	0.680	2.100	0.056	0.072	0.090
75/03/08	10	45	0.430	0.550	0.010	0.035	0.040
75/03/14	11	05	0.439	0.500	0.015	0.045	0.050
75/05/18	11	15	0.375	0.450	0.020	0.030	0.030
75/05/19	11	05	0.660	0.600	0.010	0.070	0.160
75/05/29	16	00	0.470	1.200	0.025	0.035	0.050
75/09/21	10	30	0.640	0.700	0.065	0.040	0.050
75/10/20	11	00	0.600	0.200	0.010	0.040	0.050